Presentation Agenda

• Overview
• Compliance Development
• USB4™ Testing
• Certification Process
• Summary & Questions
Presentation Agenda

• Overview
  • Introduction
  • Benefits of Certification
  • Certification Categories
  • Required Testing
  • Compliance Timeline

• Compliance Development
• USB4™ Testing
• Certification Process
• Summary & Questions
Introduction

• Goals:
  • High Quality Certified USB4 Products
  • Stable, Repeatable, Well Documented Tests
  • Instantly Available Testing
    • Qualified Test Houses
  • Minimize Test Equipment Costs
    • Avoid Expensive Equipment As Possible

• Approach
  • Build on USB 3.x Compliance Program Infrastructure
    • Extend and Reuse USBCV
    • Extend Compliance Device Infrastructure
    • Extend and Reuse Test Services Infrastructure
  • Engage with Test Equipment Vendors
  • Complex technology → enhanced testing

Use BKMs from USB and Thunderbolt™ compliance
Benefits of Certification

- Guarantees interoperability
- Add value, assurance of quality
- Help with debug/troubleshooting
- New product categories get access to PIL and subject matter experts
- Logo and Icon Usage
# USB4™ Certification Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>USB 20Gbps</th>
<th>USB 40Gbps</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB4 Host</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>USB4 Hub</td>
<td>Not Allowed</td>
<td>✓</td>
</tr>
<tr>
<td>USB4-Based Dock</td>
<td>Not Allowed</td>
<td>✓</td>
</tr>
<tr>
<td>USB4 Peripheral Device</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>USB4 Active Cable</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>USB4 Passive Cable</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Required Testing – USB4 Hubs/Docks

- USB PD Compliance
- USB Type-C® Compliance
- USB 2.0 Compliance
- USB 3.2 Compliance
- USB4™ Compliance
Required Testing – USB4 Hubs/Docks

- **USB PD Compliance**
- **USB Type-C® Compliance**
- **USB 2.0 Compliance**
- **USB 3.2 Compliance**
- **USB4™ Compliance**
Required Testing – USB4 Hubs/Docks

- USB PD Compliance
- **USB Type-C® Compliance**
- USB 2.0 Compliance
- USB 3.2 Compliance
- USB4™ Compliance
Required Testing – USB4 Hubs/Docks

• USB PD Compliance
• USB Type-C® Compliance
• **USB 2.0 Compliance**
• USB 3.2 Compliance
• USB4™ Compliance
Required Testing – USB4 Hubs/Docks

- USB PD Compliance
- USB Type-C® Compliance
- USB 2.0 Compliance
- **USB 3.2 Compliance**
- USB4™ Compliance

![Diagram of USB4 Hubs/Docks with components like USB-C, DP Source/Sink, PCIe Switch, Device Router, USB PD Controller, and USB 3.2 and 2.0 Hubs.]
Required Testing – USB4 Hubs/Docks

- USB PD Compliance
- USB Type-C® Compliance
- USB 2.0 Compliance
- USB 3.2 Compliance
- **USB4™ Compliance**
  - Tunneling
  - TBT3-Compatibility
Required Testing - USB4 Hosts

- USB PD Compliance
- USB Type-C® Compliance
- USB 2.0 Compliance
- USB 3.2 Compliance
- USB4™ Compliance
  - DP and USB3 Tunneling
  - If supported:
    - PCIe Tunneling
    - TBT3-Compatibility

![Diagram showing USB-C, DP Source/Sink, PCIe Controller, Host Router, USB PD Controller, USB 3.2 Host, and USB 2.0 Host connections]
Required Testing - USB4 Peripheral Devices

- USB PD Compliance
- USB Type-C® Compliance
- USB 2.0 Compliance
- USB 3.2 Compliance
  - If supported
- USB4™ Compliance
  - If supported:
    - DP Tunneling
    - USB3 Tunneling
    - PCIe Tunneling
    - TBT3-Compatibility

If support DP or PCIe tunneling, must support equivalent USB function (if available)
Equivalent USB Function

• A USB4 device must expose an equivalent USB function on USB 3.x or USB 2.0 (if it exists) when connected to a host that does not support the required USB4 capabilities
• If an equivalent USB function does not exist, the USB4 device must Billboard (USB 2.0)

<table>
<thead>
<tr>
<th>Equivalent Function Exists</th>
<th>No Equivalent Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USB4 Host</strong></td>
<td><strong>USB 3.2 Host</strong></td>
</tr>
<tr>
<td>USB4 Storage Device</td>
<td><strong>USB4 Monitor</strong></td>
</tr>
<tr>
<td>Must Expose USB Mass Storage Class Function</td>
<td>Must Billboard</td>
</tr>
</tbody>
</table>

Example: PCIe-based USB4 storage device connected to USB4 Host that does not support PCIe Tunneling

Example: USB4 monitor connected to USB 3.2 host
USB4 Compliance Timeline

Phase 1
End of 2019
- USB4™ certification for hosts, hubs, docks, devices, and cables
- Rev 1.0 CTS

Phase 2
Mid-2020
- Expanded compliance testing
- Stretch Goal = USB4™ testing at compliance workshops

Phase 3
End of 2020
- Additional host architectures and OS
- Updated CTS
Presentation Agenda

• Overview
• Compliance Development
  • CTS Development
  • Compliance Process
  • Test Coverage
• USB4™ Testing
• Certification Process
• Summary & Questions
Everything Starts with the Specification...

Design to specification not compliance tests!!!
Compliance Test Specification (CTS) Development

1) Generate Assertions

6. Immediately after sending the DLE symbols, send the AUT a Write Command with the following:
   a. Target = Register 9 (Metadata)
   b. Length = 4
   c. Command Data = FFFF FFFFh
7. Waiting for a Write Response from the AUT
8. Send the AUT a Read Command with the following:
   d. Target = Register 9 (Metadata)
   e. Length = 4
9. Verify that the contents of Register 9 are the same as previously written (FFFF FFFFh)
   (4.1.1.2.4#2)

2) Assertion Disposition

- Shall
- Can
- May
- Recommend
- Should

3) Write Tests and Map Assertions

4.1.1.2.4 AT and RT Transaction Rules

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.1.2.4#1</td>
<td>NT: A transmitter shall not abort an AT Transaction or an RT Transaction after the STX symbol is sent.</td>
</tr>
<tr>
<td>4.1.1.2.4#2</td>
<td>TD 4.3: When a receiver receives two or more leading DLE symbols, it shall discard the extra leading DLE symbols and process the received LT Transaction as if only one leading DLE symbol was received.</td>
</tr>
</tbody>
</table>

4) Review, Revise, and Build

USB4™ Spec
USB4™ CTS
Compliance Process Overview

Compliance Test Specs
- Interprets
  - Spec Requirements
- Defines
  - Test Assertions
  - Specific Test Requirements
  - Test Algorithms

Test Tools And Procedures
- Test H/W & S/W
  - Validates
  - Test Criteria
    - Compliance
    - Interoperability

Clear Test Output Maps Directly to Test Spec

Workshops Test Houses
- PASS
- FAIL

Predictable Path To Compliance
Test Coverage

• Compliance is not a replacement for validation
• Tests attempt to approximate:
  • Common and corner cases
  • Error and non-error cases
  • Implementation variations across different hosts
• Not testing cases of bad SW
  • For example, cases where Connection Manager configures Router incorrectly or sends unexpected packet
Presentation Agenda

• Overview
• Compliance Development
• USB4™ Testing
  • USB4™ Test Matrix
  • Thunderbolt™ 3 Compatibility Testing
  • Test Tools
• Certification Process
• Summary & Questions
Silicon vs. End Product

Silicon

Physical component that gets integrated into product

End Product

Product that end user can go buy
# USB4™ Test Matrix

<table>
<thead>
<tr>
<th></th>
<th>Host Silicon</th>
<th>Host End Product</th>
<th>Dock Silicon</th>
<th>Dock End Product</th>
<th>Hub Silicon</th>
<th>Hub End Product</th>
<th>Device Silicon</th>
<th>Device End Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Logical Layer</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Protocol</strong></td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><strong>TMU</strong></td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><strong>H2H Tunneling</strong></td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td><strong>USB3 Tunneling</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>If Supported</td>
</tr>
<tr>
<td><strong>DP Tunneling</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>If Supported</td>
</tr>
<tr>
<td><strong>PCIe Tunneling</strong></td>
<td>If Supported</td>
<td>If Supported</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>If Supported</td>
</tr>
<tr>
<td><strong>USB4 Interop</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>TBT3-Compatability</strong></td>
<td>If Supported</td>
<td>If Supported</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>If Supported</td>
</tr>
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<td>✓</td>
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<td></td>
<td></td>
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<td>✓</td>
<td>✓</td>
<td></td>
</tr>
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<td><strong>Logical Layer</strong></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Protocol</strong></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>×</td>
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</tr>
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<td><strong>TMU</strong></td>
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<td>×</td>
<td></td>
</tr>
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<td>✓</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>×</td>
<td></td>
</tr>
<tr>
<td><strong>USB3 Tunneling</strong></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP Tunneling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>×</td>
<td></td>
</tr>
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<td><strong>PCIe Tunneling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>If Supported</td>
</tr>
<tr>
<td><strong>USB4 Interop</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>TBT3-Compatability</strong></td>
<td>If Supported</td>
<td>If Supported</td>
<td></td>
<td></td>
<td></td>
<td>(DFP only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Takeaways:

1. There is a lot of testing!
2. End product testing is a subset
3. If a feature is supported, it is tested
4. If a feature is not supported, look for graceful fallback
USB4™ Test Suite Summary

**Electrical**
- Gen 2 and Gen 3 speeds
- Rx and Tx compliance
- USB4 Link and SB Channel

**Logical Layer**
- Transactions
  - Lane Initialization
  - Link transitions
  - Link errors
  - Sleep/wake

**Protocol**
- Routing
  - Flow Control
  - Control Packets
  - Configuration Space

**TMU**
- Time sync handshakes
- Parameter calculation
- Single and Inter-Domain

**Tunneling**
- Encapsulation
- Protocol specific behavior
- Path setup and Teardown

**Host Interface**
- Control Interface
  - Host-to-host tunneling
  - E2E flow control

**Interop**
- USB4 products
  - DP, PCIe, USB 3.x, and USB 2.0 devices
  - Thunderbolt 3 products

**TBT3-Compatibility**
- Testing included in other test suites

**Ch3**
**Ch4**
**Ch5**
**Ch6**
**Ch7**
**Ch8**
**Ch9**
**Ch10**
**Ch11**
**Ch12**
**Ch13**
USB4™ Test Tools

• Electrical Test Tools
  • Test Fixtures
  • Real Time Scope
  • Pattern Generator
  • Network Analyzer
  • Signal Generator

• USB4 Exerciser
  • Logical layer testing
  • Generate error cases

• USB4 Analyzer
  • Primarily used for protocol and tunneling testing

• Clock Signal Analyzer
  • TMU Testing

• USB4 Compliance Device
  • Generates loopback USB4 traffic

• USB4CV
  • Primary SW test tool
  • Builds on existing USB CV
  • Will be available to download on USB.org
  • First gen works on Win10, x64, PCIe-based host
Example USB4CV Output
Presentation
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• Certification Process
  • Process Overview
  • Pre-Certification Requirements
  • Test Venues
• Summary & Questions
USB4 Certification Process Overview

1. Pass USB 2, USB 3.2, USB PD, and USB Type-C® compliance tests
2. Complete USB4™ Pre-Certification testing and requirements
3. Submit product for certification
4. Perform USB4 Compliance testing at test lab
5. Send test results to USB-IF
6. Get notification from USB-IF with status (pass or fail)
Pre-Certification Testing and Requirements

• Generate Vendor Info File (VIF)
• Show that used certified components
  • Certified Connector
  • Certified Silicon (if end product)
• Run subset of USB4™ compliance tests and produce logs

Will be posted on www.USB.org
USB4™ Test Venues

- Independent Test Labs (ITLs)
- Product integration Lab (PIL)
- Workshops (eventually ...)
Presentation Agenda

- Overview
- Compliance Development
- USB4™ Testing
- Certification Process
- Summary & Questions
  - Key Takeaways
  - Q&A

Q&A
Key Takeaways

★ It’s a lot of testing !!!
★ Certify in layers – need to use certified USB components
★ USB4™ Compliance follows compliance BKMs
★ Perform in your own lab as part of validation
Time for Q&A